

SUBJECT: Crew Sleep Cycles During the First
AAP Mission - Case 610

DATE: November 17, 1969

FROM: D. J. Belz

ABSTRACT

Several aspects of the decision to use a 23.5-hour astronaut sleep cycle, in place of the "natural" 24-hour cycle, are analyzed. It is recommended that 24-hour crew sleep cycles be employed during AAP missions, assuming that:

1. An Intelsat IV terminal is provided in the Workshop, and
2. EVA's can be scheduled both outside the South Atlantic Anomaly and during periods of frequent direct contact with the MSFN.

If these assumptions are not realizable, it is recommended that 23.5 hour crew sleep cycles be employed, provided AAP-1 is launched in the late afternoon as presently planned.

In view of the relative lack of experience with 23.5 hour sleep cycles and the significant disruption of flight plans that could result from an astronaut's inability to adapt to such a sleep pattern, it is further recommended that if shortened sleep cycles are to be used during AAP missions:

1. Consideration be given to ground based tests to demonstrate feasibility, and
2. Astronaut training for the AAP-1/AAP-2 mission include a reasonable period of time on a 23.5 hour sleep cycle routine to determine individual adaptability and to provide an opportunity for gathering baseline data on the crews' performance for later comparison with in-flight results.

These recommendations are in part based on a Workshop orbital inclination of 35°. The effect of the recent baseline change to a 50° inclination will be examined in a forthcoming memorandum.

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MEMORANDUM FOR FILE

1.0 Introduction

Flight planning for AAP missions has, until recently, employed 24-hour astronaut sleep cycles, phased in such a way that the concurrent sleep periods of two men occurred while the third man was awake (References 1-3).^{*} Present flight plans for AAP provide concurrent sleep periods for all three crewmen and 23.5-hour crew sleep cycles (Reference 4). The change from staggered to concurrent in-flight sleep periods reflects current astronaut preference. The use of 23.5-hour sleep cycles during AAP missions, in place of a "normal" 24-hour day, was proposed by W. E. Koons - MSC/FA primarily to permit AAP astronauts to be awake and active during the period of best spacecraft/ground communications coverage throughout each flight.

The choice of a shortened crew sleep cycle as opposed to a 24-hour cycle affects and is affected by a number of diverse factors including:

1. Launch Windows and Recovery Opportunities,
2. Spacecraft/Ground Communications,
3. EVA considerations, and
4. Qualitative considerations such as:
 - a. Physiological Effects of a 23.5-hour sleep cycle,
 - b. Effects on Medical Monitoring Experiments, and
 - c. Flight-Crew Preference.

^{*}A sleep cycle is defined herein as a continuous, scheduled sleep period plus the subsequent continuous period of wakefulness. Thus a "normal" 24-hour astronaut sleep cycle consists of 8 hours of scheduled sleep plus 16 hours of wakefulness; the 23.5-hour sleep cycle discussed in this memorandum consists of 8 hours of scheduled sleep plus 15.5 hours of wakefulness.

This memorandum explores these factors and comments upon the relative advantages and disadvantages of a shortened sleep cycle.

Calculations of recovery opportunities, communication contacts with the ground, and spacecraft passages through the South Atlantic Anomaly referred to in this memorandum were performed with the BCMASP Earth Orbit Simulator and TSAP programs (References 5 and 6). Except where noted otherwise, the following mission parameters are used throughout this memorandum:

Dry Workshop Initial Orbital Altitude = 235 nm

Orbital Inclination = 35°

AAP-1 Launch Date = March 15, 1972.

2.0 Launch Windows and Recovery Opportunities

Launch opportunities for AAP manned missions are constrained by many factors including: (1) the need to launch when the launch-site is nearly in the orbital plane of the previously launched Dry Workshop; (2) a requirement to launch only on northerly azimuths; (3) the desire to launch in daylight; and (4) the desire to splashdown and recover the crew in daylight at the end of a nominal mission.

The essentially in-plane launch requirement for AAP-2, 3, and 4 is a consequence of the limited ΔV capabilities of the Saturn-IB launch vehicle and the payload to be delivered to orbit. The launch site passes through the Workshop's orbital plane twice each day. The requirement to use only northerly azimuths eliminates one of those daily opportunities, leaving one usable in-plane launch opportunity per day. As a result of orbital precession, these opportunities occur approximately one-half hour earlier on each succeeding day. Thus, for example, if AAP-1 were launched at sunset on a spring day when the duration from sunrise to sunset is approximately twelve hours, daylight launch opportunities for AAP-2 would occur during at least the next twenty-four succeeding days.

Recovery of the AAP-2 command module following a nominal 28-day mission is to occur in the Western Atlantic Recovery Zone, centered approximately at Bermuda (Reference 7).

Figure 1 indicates times of passage over the Western Atlantic Recovery Zone by the orbiting AAP-1/AAP-2 spacecraft. It is based on Reference 8 and computations performed with the BCMASP Earth Orbit Simulator. The center of the Western Atlantic Recovery Zone was assumed to be located at 30° North Latitude, 64.75° West Longitude. In general, only the two daily passes whose ground tracks approach nearest the zone's center are shown, to indicate the pattern of such passes throughout the mission.

Also shown in Figure 1 are lighting conditions at the center of the Western Atlantic Zone for AAP-1 launch times of ~8:45 AM EST and ~2:45 PM EST. Launching AAP-1 between those times will prohibit a daylight recovery in the Western Atlantic Zone on the orbital pass closest to the zone center during the 28th day of the manned mission.

Thus, to accommodate a daylight launch and daylight recovery of the AAP-2 CM, AAP-1 must be launched in the late afternoon or early morning. The afternoon launch has an advantage in that it results in an early morning splashdown allowing

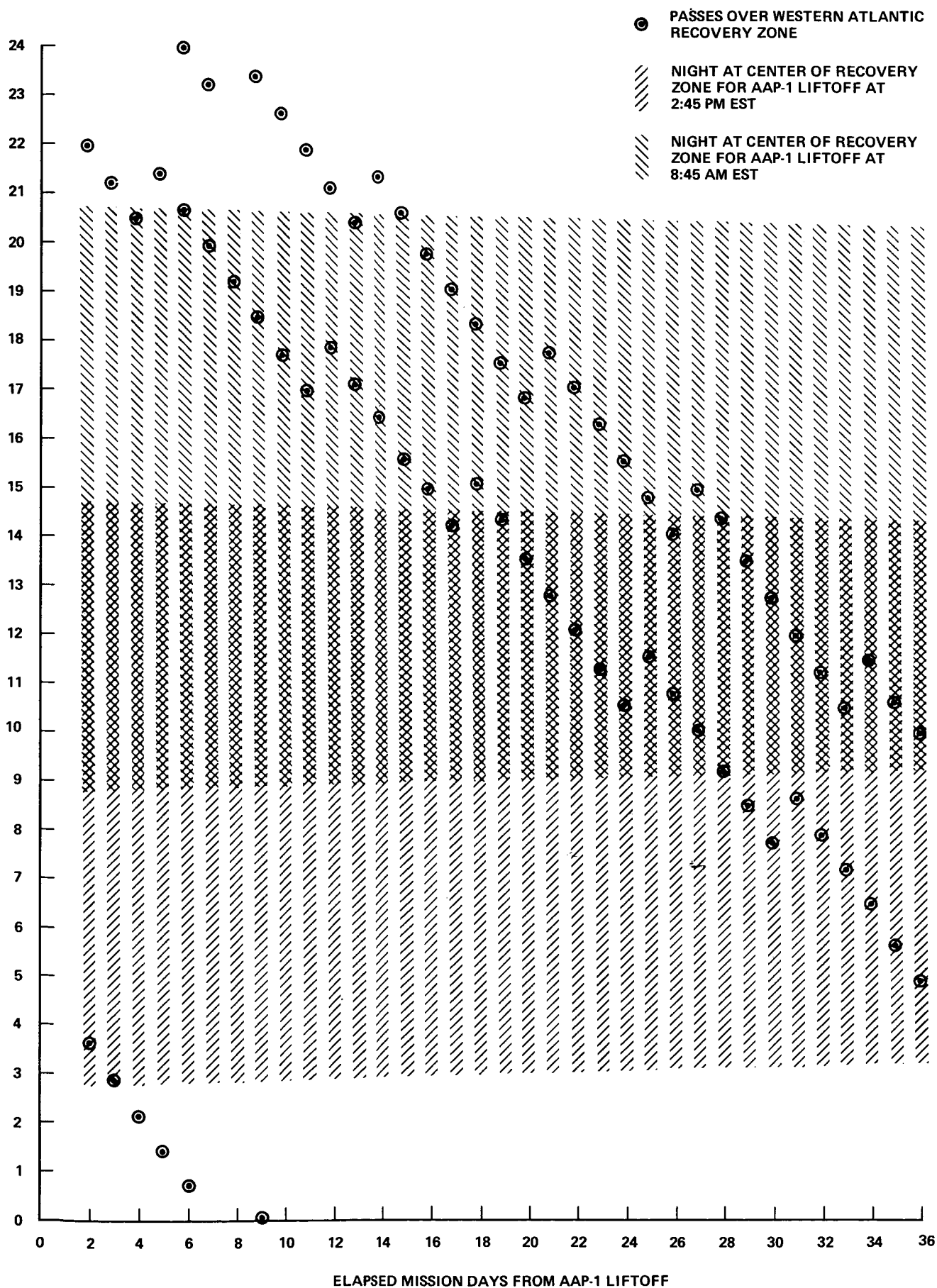


FIGURE 1. WESTERN ATLANTIC RECOVERY ZONE LIGHTING DURING THE AAP-1/AAP-2 MISSION

almost a full day's daylight for recovery of the CM, whereas a morning launch of AAP-1 results in a nominal splashdown late in the afternoon, thus allowing less time for recovery before nightfall. The current Baseline Reference Mission schedules the nominal AAP-1 launch for 4:00 PM EST (Reference 4).

From the viewpoint of crew performance and well-being it is desirable to maintain the astronauts' terrestrial sleep pattern without significant disturbance throughout launch and initial orbital operations. It is not possible to predict with precision the sleep patterns of AAP-2 astronauts during the week prior to their flight; it does however appear reasonable to assume that they will be in residence at Cape Kennedy during that week and that they will follow a normal nocturnal pattern of sleeping, i.e., with sleep beginning near 11:00 PM EST and ending near 7:00 AM EST. Based on that assumption, a 4:00 PM EST launch of AAP-1, and an AAP-2 launch 23.5 hours after AAP-1 lift-off, it follows that:

1. In order to maintain continuity with their terrestrial sleep schedule, the first sleep period in orbit for the three astronauts should occur between 1 day 7 hours GET* and 1 day 15 hours GET regardless of whether in-orbit sleep cycles are to have a duration of 24 hours or 23.5 hours.
2. A nominal splashdown of the AAP-2 command module will occur at approximately 28 days 14 hours (see Figure 1). Therefore, if the crew maintained 24-hour sleep cycles throughout the mission, they would have to awaken several hours earlier than usual from their last sleep period in space in order to prepare for and carry out deorbit and landing procedures (see Figure 2).
3. If the crew has maintained 23.5-hour in-flight sleep cycles throughout the mission, their last scheduled sleep in orbit would occur between 27 days 17.5 hours GET and 28 days 1.5 hours GET. No perturbations of their in-flight sleep schedule would be required to prepare for and execute deorbit, landing, and recovery procedures (see Figure 2).

*GET \equiv Ground Elapsed Time Measured from AAP-1 lift-off.

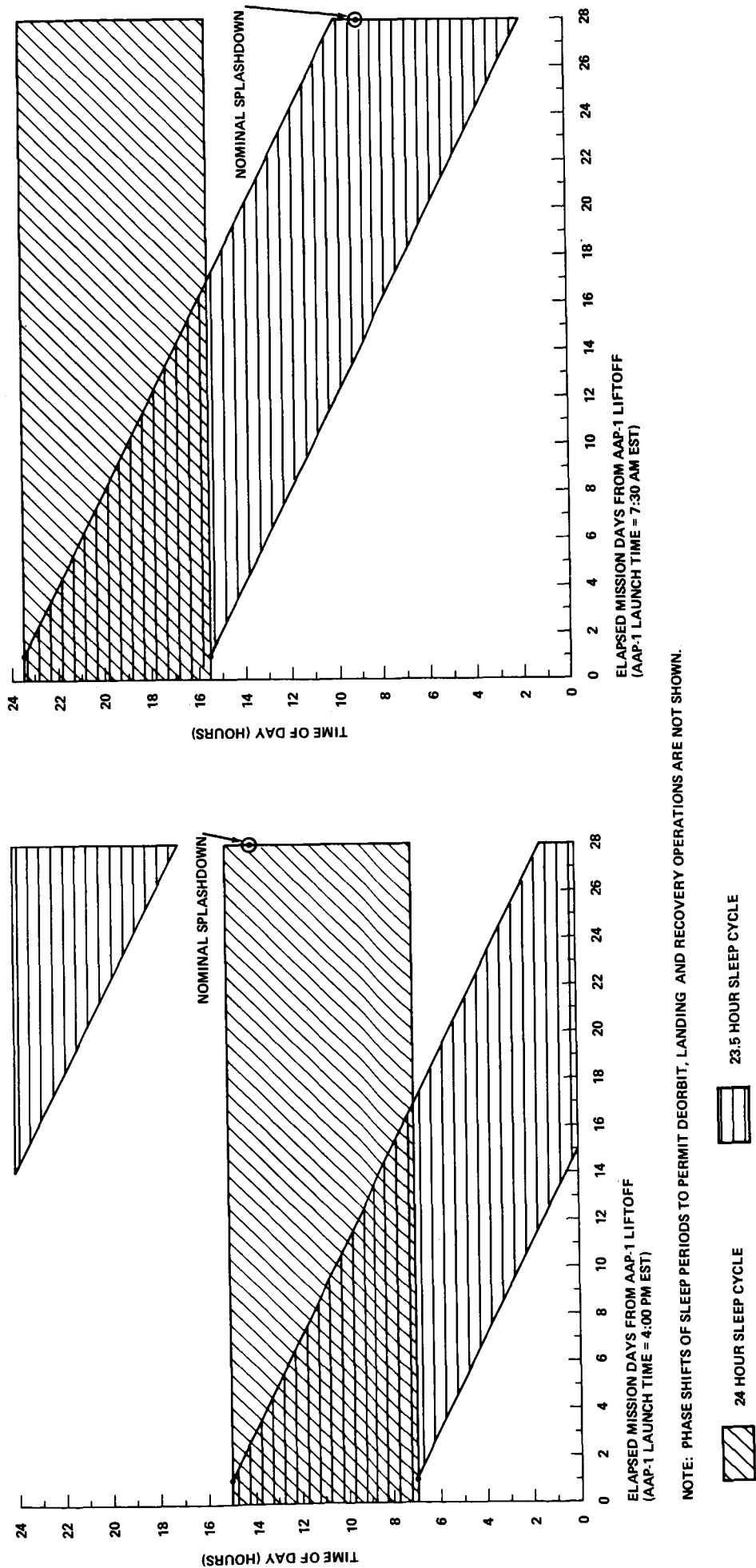


FIGURE 2. ALTERNATE INFLIGHT SLEEP PATTERNS FOR AAP-2 ASTRONAUTS

If the launch of AAP-1 occurs during the morning hours, for example at 7:30 AM EST, splashdown of the AAP-2 CM following a nominal 28-day mission will occur at ~28 days 9 hours GET (see Figure 1). If initial disturbance of the crew's sleep pattern is to be avoided, their first sleep period in orbit would occur between 1 day 15.5 hours GET and 1 day 23.5 hours GET. This would permit the crew to adhere to their preflight 24-hour sleep cycles throughout a nominal AAP-1/AAP-2 mission from launch through recovery (see Figure 2). If 23.5-hour sleep cycles are initiated at the start of the mission, the last in-flight sleep period would fall between 28 days 2 hours GET and 28 days 10 hours GET; that is, it would have to be displaced by several hours to permit the crew's being awake during deorbit operations, landing, and recovery (see Figure 2).

3.0 Spacecraft/Ground Communications

Opportunities for direct communication between the spacecraft and Manned Space Flight Network (MSFN) occur at discrete intervals throughout AAP missions. These opportunities are not, however, distributed uniformly in time. Figure 3 illustrates the variation in frequency of direct spacecraft/MSFN communication contacts during the first AAP mission. In that figure, the mission duration has been arbitrarily divided into segments fifteen minutes in length. Segments within which one or more direct contact opportunities occur are shaded; segments within which no contact opportunities occur have been left unshaded. The resulting pattern of contacts illustrates the daily cycle in frequency of direct contacts that characterizes AAP missions. In addition, the effect of precession of the spacecraft's orbital plane is shown by the regression of dense - or sparse - contact regions at an average rate of approximately 0.5 hours per mission day.

The configuration of the MSFN for AAP is not firmly established at this writing. Figure 3 is based upon an assumed AAP MSFN configuration consisting of the following stations (Reference 9):

Hawaii	}	30' Dishes
Texas		
Merritt Island		
Bermuda		
Canary		
Ascension		
Carnarvon		
Guam		
Goldstone	}	85' Dishes
Madrid		
Canberra		

A contact opportunity was considered to occur whenever the spacecraft was at an elevation greater than or equal to 5° above the horizon as viewed from any of the MSFN stations listed above.

As mentioned previously, periods of relatively frequent or dense direct contact between the spacecraft and MSFN occur cyclically, with an "irregular" period that averages approximately 23.5 hours. This effect has been the prime motivation in MSC's adoption of a 23.5-hour sleep cycle for AAP

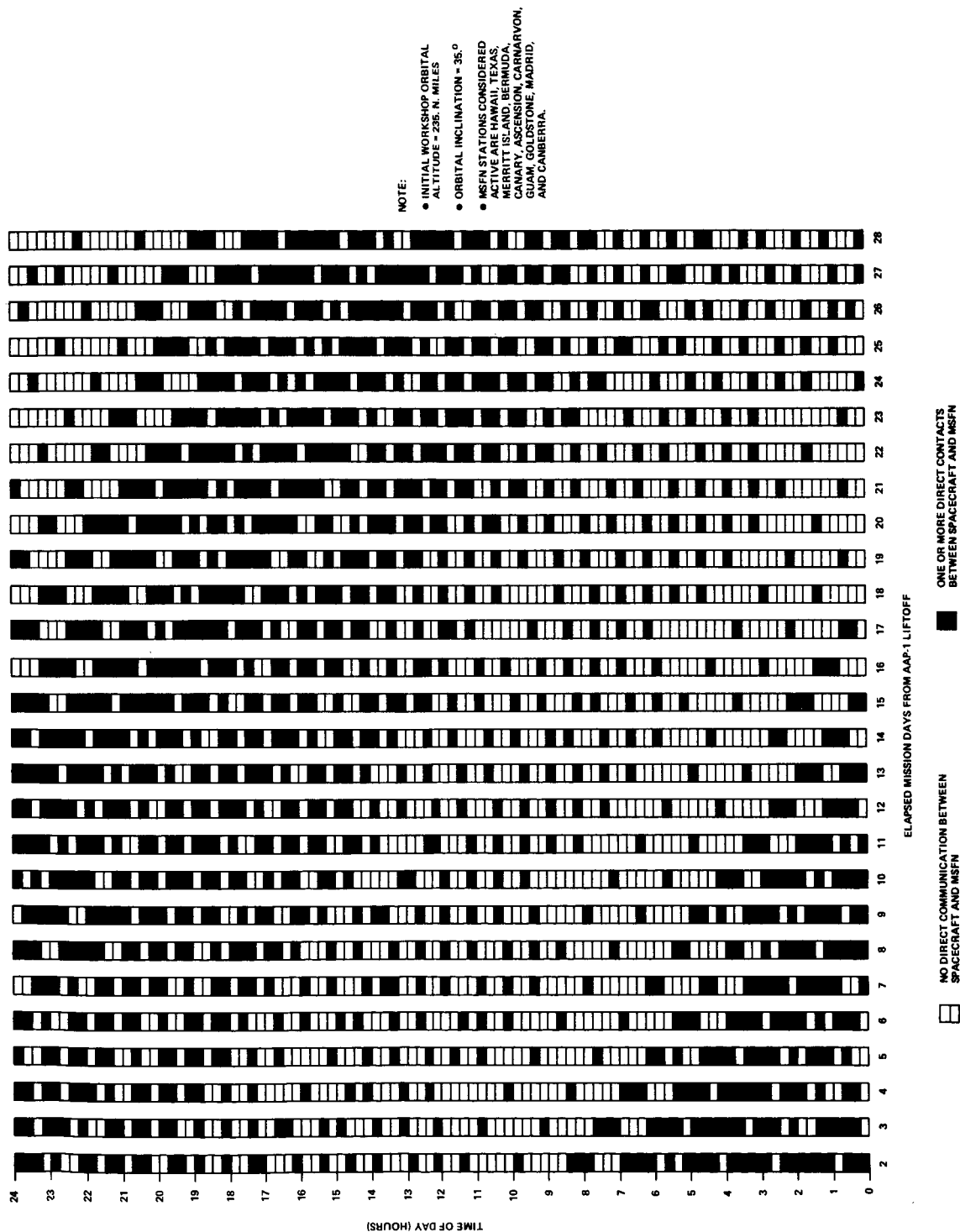


FIGURE 3. DENSITY OF DIRECT SPACECRAFT/MSFN COMMUNICATIONS CONTACTS DURING THE AAP-1/AAP-2 MISSION

astronauts. That is, it has been argued that use of a "23.5-hour day" in place of a 24-hour day would permit the crew to be awake each mission "day" during the period of most frequent direct MSFN contacts, thereby facilitating communication with the ground (Reference 10).

Figure 4 illustrates some aspects of these alternatives. The in-flight sleep patterns of Figure 2 are superposed on a pattern of dense versus sparse MSFN contacts derived from Figure 3. The precise boundary of the dense region is defined arbitrarily; the main outlines of the pattern are, however, relatively clear.

From Figure 4 it is apparent that if the crew continues a nocturnal terrestrial sleep pattern throughout the flight without alternation of phase or period:

1. A 4:00 PM EST launch of AAP-1 followed a day later by the launch of AAP-2 will result in:
 - a. the crew being awake during times of most frequent direct contact with the MSFN throughout the first third of the mission, and
 - b. a gradual (1/2 hour per day) "slipping" of such favorable direct contact times into the crews' sleep period on each successive day thereafter.
2. A 7:30 AM EST launch of AAP-1 followed a day later by the launch of AAP-2 will result in partial availability of the most favorable direct MSFN contact periods while the crew is awake early and again late in the mission, while such periods will be largely unavailable during the middle of the mission.

If, following CSM/Workshop docking, the crew initiates and thereafter maintains 23.5-hour sleep cycles without a phase shift relative to a nocturnal terrestrial sleep cycle, it follows that:

1. A 4:00 PM EST launch of AAP-1 followed a day later by the AAP-2 launch will result in the astronauts being awake during periods of most frequent direct contact with the MSFN throughout the mission.
2. A 7:30 AM EST launch of AAP-1 will, aside from causing the crew to awaken at an abnormally early hour on the following day for the AAP-2 launch, result in the availability of ~2/3 of the best direct MSFN coverage each day throughout the mission

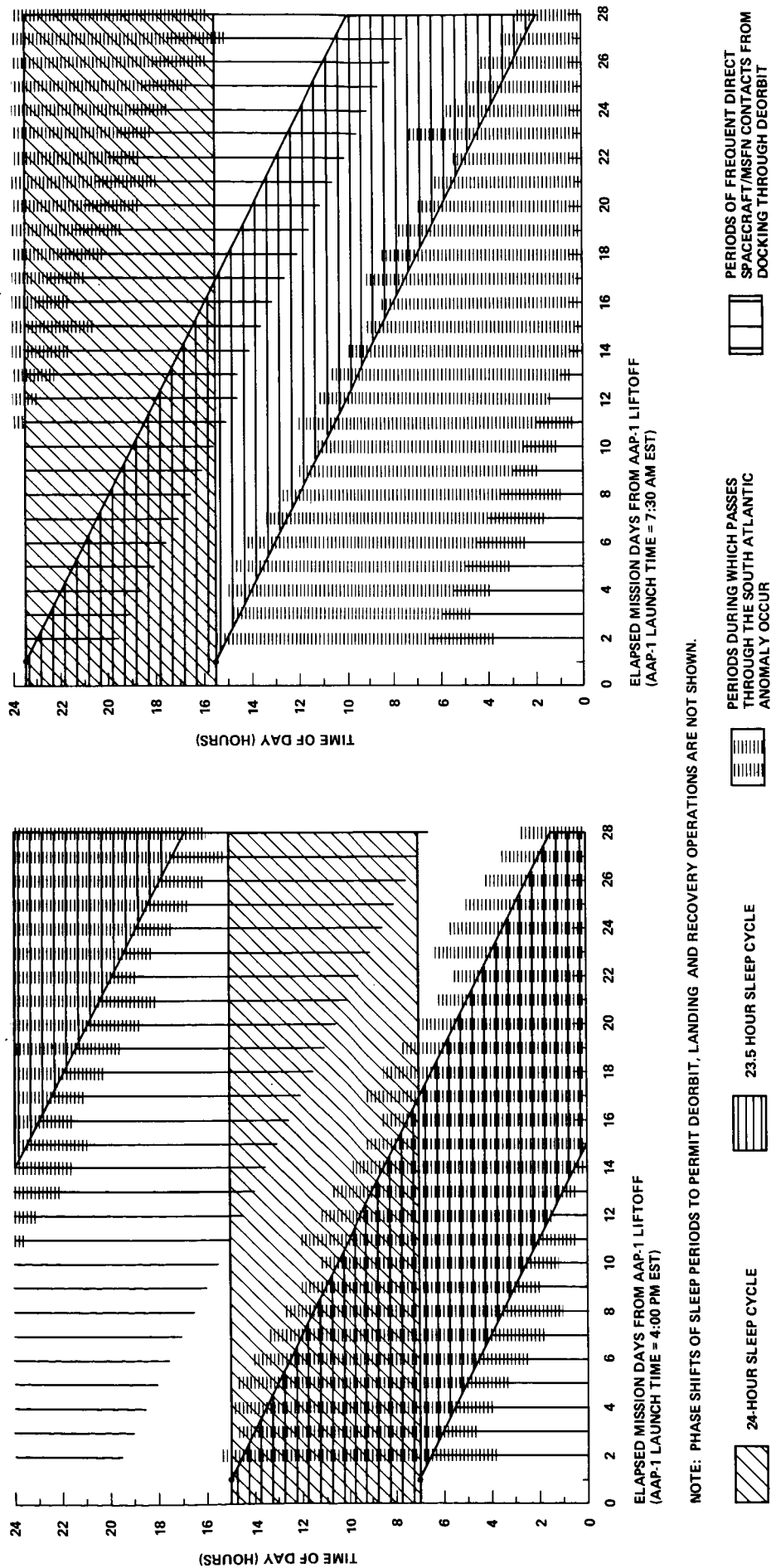


FIGURE 4. RELATION OF REPRESENTATIVE SLEEP PATTERNS TO PERIODS OF FREQUENT DIRECT SPACECRAFT/MSFN CONTACTS AND PASSES THROUGH THE SOUTH ATLANTIC ANOMALY

while the crew is awake. This fraction could be improved substantially by a one or two hour phase shift early in the mission; it will also be affected by the crews' actual sleep pattern prior to launch and the actual number of days between the launches of AAP-1 and AAP-2.

The installation of an Intelsat IV terminal in the Workshop is presently under consideration; this facility would, in conjunction with two Intelsats, provide "indirect" voice communication between the spacecraft and MSFN during ~80% to ~90% of the mission. Such nearly continuous coverage would essentially remove the original motivation for 23.5-hour astronaut sleep cycles during AAP missions. However, opportunities for live television broadcasts to the ground would still be possible only during periods of direct spacecraft/MSFN contacts (Reference 9).

4.0 EVA Considerations

No formal requirements concerning EVA presently influence the choice of a 23.5 versus a 24-hour astronaut sleep cycle. Considerations of spacecraft/ground communications and radiation exposures may, however, affect the scheduling of EVA's.

During EVA, astronauts are exposed to risks not encountered when they are encapsulated in their spacecraft. Crewmen are physically separated from one another, the extra-vehicular crewmen cannot return instantly to the spacecraft's interior in the event of emergency, nor can the astronaut remaining inside the cluster instantly join his fellow crewmen outside the spacecraft. In the event of any malfunction or anomalous behavior in the spacecraft's systems, whether directly related to the EVA or not, it will be desirable to have ground monitoring of telemetry, and advice from mission control, available. It is therefore presumed to be desirable that EVA's be conducted during periods of relatively frequent direct contact between the spacecraft and the MSFN.

The maximum planned duration of AAP EVA's is 3 hours. Figures 3 and 4, as discussed above, indicate that all hours of relatively frequent, direct contact between the spacecraft and MSFN are available during each mission day. The location of such periods of direct contact in relation to representative crew sleep periods is shown in Figure 4 and discussed in the preceding section of this memorandum.

It is not certain at this writing whether the Intelsat IV terminal being considered for installation in the Workshop will be configured to provide communication between extravehicular astronauts and the ground. If voice communication between EVA crew members and the ground is not to be available through Intelsat IV, it will only be available when the spacecraft is in line-of-sight contact with an MSFN station. In either case, the Intelsat IV communications link will not permit all spacecraft telemetry to be sent to the ground simultaneously, whereas direct contact between the spacecraft and MSFN does permit all telemetry to be transmitted simultaneously. It therefore appears desirable to schedule EVA's during periods of relatively frequent, direct spacecraft/MSFN contact, regardless of whether the Intelsat IV terminal is available or not.

The amount of ionizing radiation to which the crew of the first AAP mission will be exposed is not presently thought to exceed reasonable levels for mission planning purposes. Nevertheless it is presumed that exposure to such radiation in any amounts is undesirable if avoidable.

Virtually the entire radiation dose received in flight by AAP astronauts will result from passages through the South Atlantic Anomaly (Reference 11). Since the amount of radiation shielding provided by a space suit is significantly less than that provided by the Workshop to its occupants, it appears desirable to avoid scheduling extravehicular activity during periods of passage through the Anomaly.

For the purposes of this study the South Atlantic Anomaly is considered to extend over the region shown in Figure 5. Times of passage through the Anomaly were calculated with the BCMASP Earth Orbit Simulator and TSAP programs (References 5 and 6). The boundary of the Anomaly itself was approximated by the net outer boundary of 19 overlapping circular regions of 600 nm radius, centered at the following locations:

South Latitude (°)	Longitude (°)
30	60 W
20	50 W
20	40 W
20	30W
20	20 W
20	10 W
30	0
40	10 E
45	0
45	10 W
45	20 W
45	30 W
45	40 W
40	50 W
35	55 W
30	40 W
30	30 W
30	20 W
30	10 W

That boundary roughly approximates the 10 protons/CM²-sec isoflux line of Figure 5.

The Anomaly, as defined above, is encountered seven times per mission day, the maximum duration of each encounter being approximately twenty minutes. Regions of mission time, during which passes through the Anomaly occur, are shown in Figure 4.

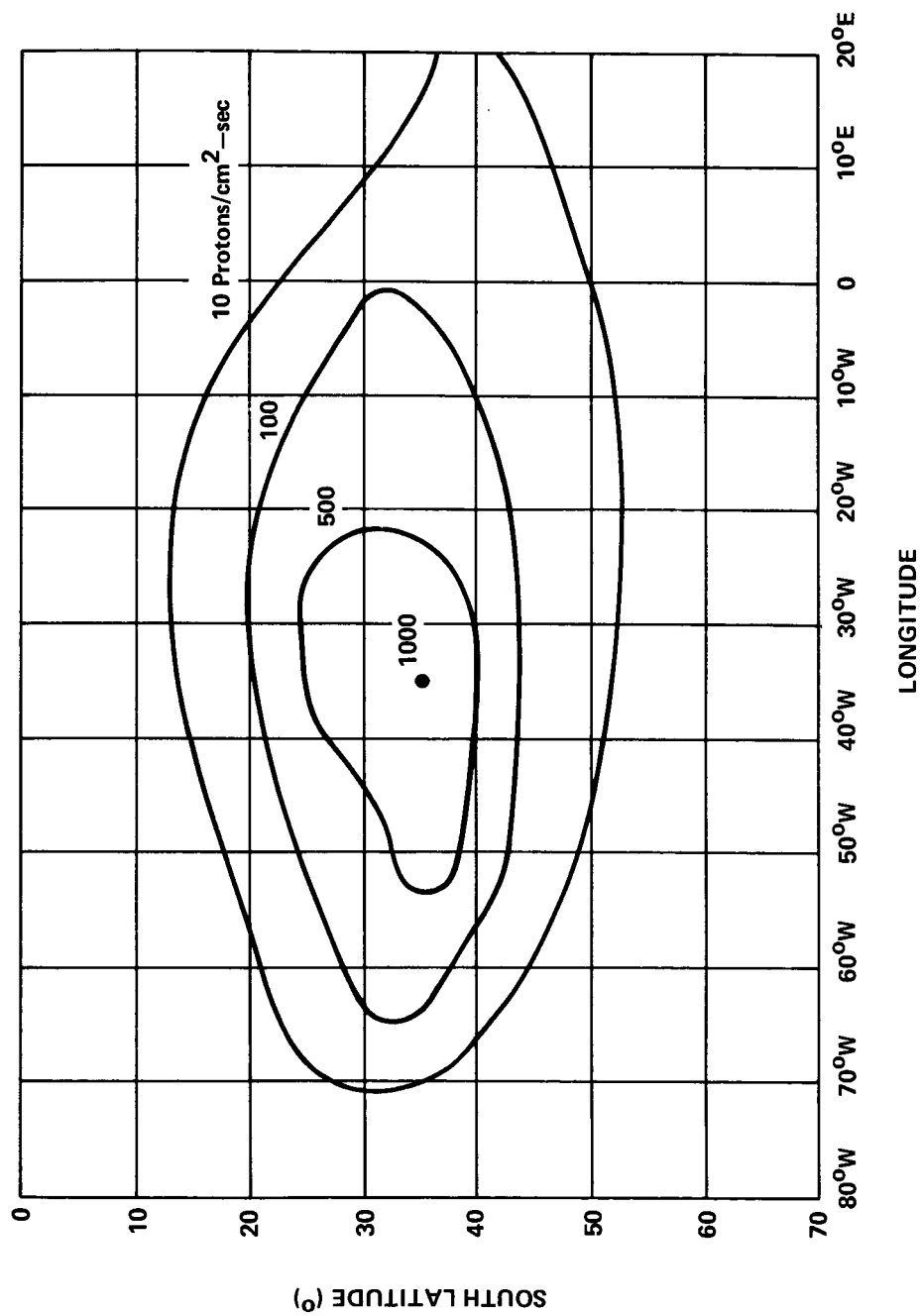


FIGURE 5. PROTON ISOFLUX PLOT AT AN ALTITUDE OF 240 N. MILES IN THE SOUTH ATLANTIC ANOMALY (FROM REFERENCE 11)

Fortunately, periods of frequent direct spacecraft/MSFN contacts overlap periods during which the South Atlantic Anomaly is encountered by only 2 or 3 hours per day. Thus, approximately 8 or 9 hours per day are available during which the South Atlantic Anomaly is not encountered and frequent, direct spacecraft/MSFN communications opportunities exist.

If EVA is to be scheduled only during such periods, the following observations can be made (see Figure 4):*

1. For a 4:00 PM EST launch of AAP-1:
 - a. Adherence to the crews' 24-hour terrestrial sleep cycle without alteration of phase or period throughout the mission will provide daily opportunities for scheduling EVA from CSM/Workshop docking through Day 17 GET.
 - b. The use of a 23.5-hour sleep cycle without an initial phase shift relative to a terrestrial nocturnal sleep pattern will provide 8 or 9 hours per day of EVA scheduling opportunities throughout the mission.
2. For a 7:30 AM EST launch of AAP-1:
 - a. Adherence to the crews' preflight (nocturnal) sleep pattern during the mission will provide daily opportunities for scheduling EVA on and beyond Day 21 GET.
 - b. The use of 23.5-hour sleep cycles without an initial phase shift relative to preflight sleep patterns will provide essentially no opportunities for scheduling 3-hour EVA periods during the mission; an initial regressive phase-shift of 2 hours in the astronauts' sleep pattern would, however, provide such scheduling opportunities on each mission day.

*These observations take into account requirements for 2 hours of EVA preparation by each crewman, an allowance of 1 hour for dinner and for breakfast immediately before and after each sleep period, and an allowance of 1 hour for post-EVA stowage and suit-drying operations.

5.0 Qualitative Considerations

The preceding discussions were concerned with easily quantifiable factors pertinent to the selection of a crew sleep cycle for AAP. This section is concerned with factors that may be no less important, but that are nonetheless difficult or impossible to quantify.

5.1 Physiological Effects of a 23.5-Hour Sleep Cycle

Nothing definitive can be said by way of predicting the physiological effects of a 23.5 hour in-flight sleep cycle on AAP astronauts. There are, however, two questions that are worth considering if such a sleep cycle is to be used in operational mission planning:

1. Can the Crew Adapt to a Pattern of "Falling Asleep a Half-Hour Earlier Every Day"?

Observations have been conducted of humans living for weeks on abnormal time routines where the length of the "day" was constant, but other than 24 hours. Studies in which the "day" was as little as 21 hours in duration or as much as 28 hours in duration showed that most, but not all, subjects adapted their sleep patterns to the unusual routine (Reference 12). Some subjects exhibited a tendency to resist the artificial "day" by adhering to a 24 hour sleep cycle despite a physical and social test environment that tended to discourage such behavior. Regardless of the duration of the "day," the overall amount of time spent sleeping was voluntarily maintained at about one-third of the test duration.

During the Gemini VII mission, sleep periods were scheduled in an irregular pattern very roughly approximating a 23.5 hour sleep cycle. Figures 6 and 7 illustrate the scheduled and actual sleep periods of the Gemini VII astronauts as reported in Reference 13.

From these figures it is apparent that the pilot experienced no difficulty in falling asleep "on schedule" during the first four days of the mission. Thereafter an irregularly widening gap between the scheduled start of sleep periods and the actual onset of sleep is noticable. A similar, although not identical, phenomenon can be seen in the command pilots' sleep pattern. In the absence of other information it is well not to make too much of the significance of Figures 6 and 7; many factors could have contributed to the actual sleep patterns shown, e.g., persistence of an endogenous 24-hour circadian periodicity, deliberate departure from the schedule,

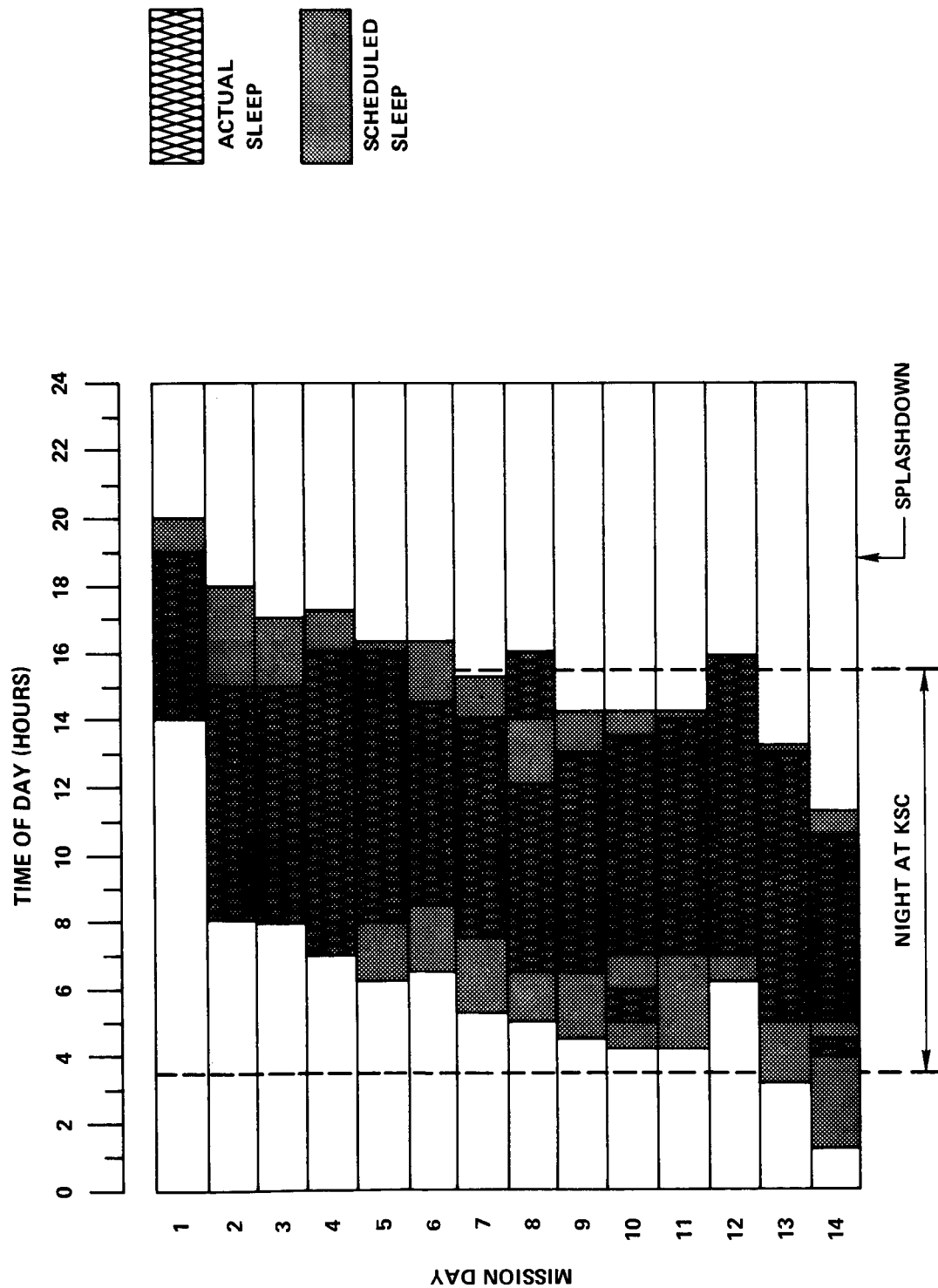


FIGURE 6. GEMINI VII PILOT'S SLEEP PATTERN (BASED ON REFERENCE 13)

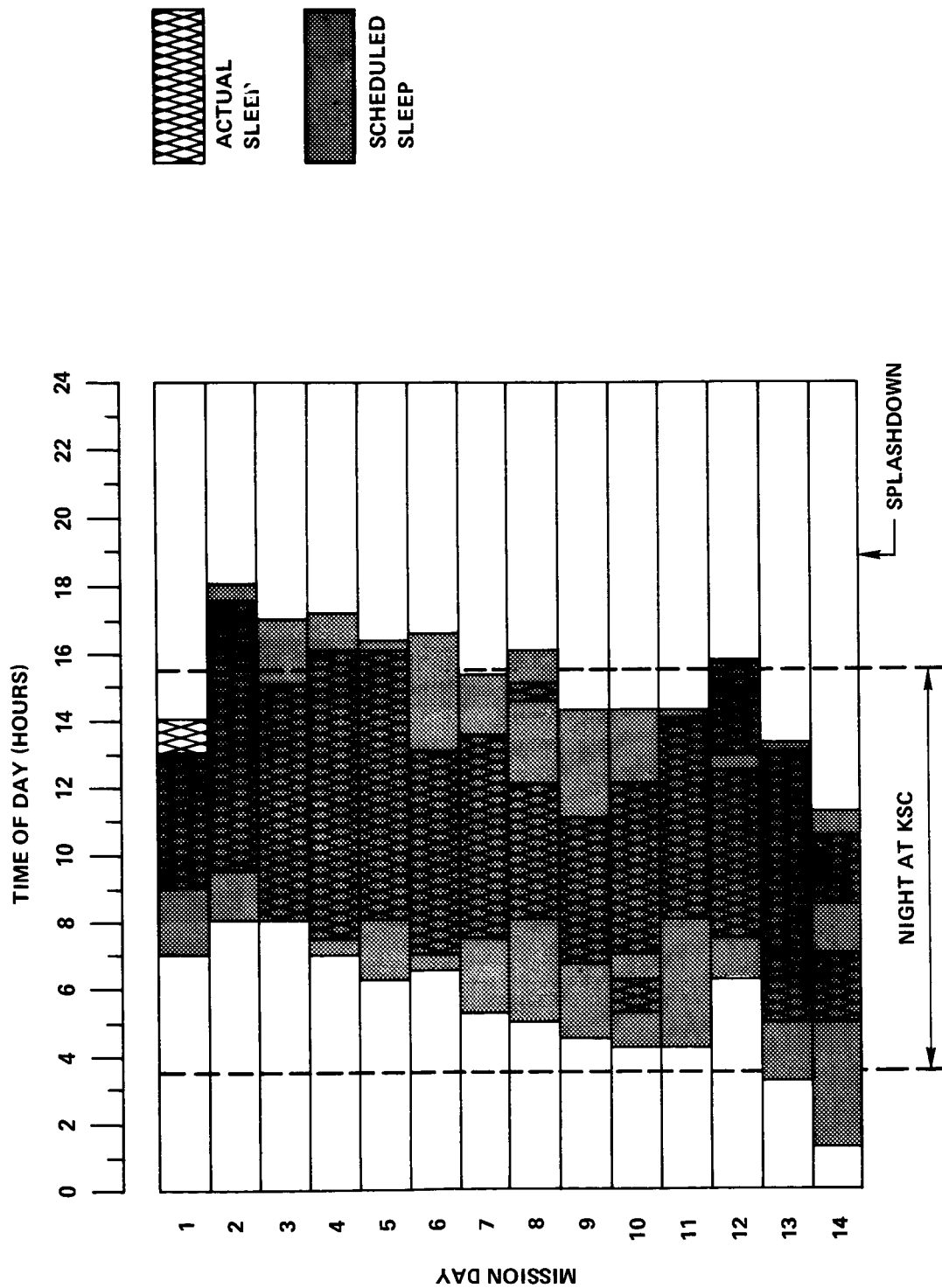


FIGURE 7. GEMINI VII COMMAND PILOT'S SLEEP PATTERN (BASED ON REFERENCE 13)

or reduced sleep requirements resulting from the low level of physical activity during the flight. Whatever the explanation, the Gemini VII sleep data do not provide a basis for concluding that undisturbed sleep on a roughly 23-1/2 hour cycle can be counted on as a matter of course in space flight. Individual variability among humans and a natural tendency to persist on a 24-hour schedule may introduce irregularities into an ideally 23-1/2 hour sleep cycle for some crewmen.

2. Could Adherence to a 23.5-Hour Sleep Cycle Adversely Affect Crew Performance?

If one presumes that the AAP-1/AAP-2 crew did adapt to a 23.5-hour sleep cycle, it is of some importance to inquire whether this departure from their normal terrestrial routine might adversely affect their performance in the in-flight execution of complex physical and mental tasks such as those involved in the operation of experiments.

For example, sensations of drowsiness and wakefulness vary circadianly and "are not the result of merely having been awake or asleep for some hours" (Reference 14); persistence of a 24-hour rhythm in the state of arousal might conceivably tend to reduce levels of alertness during "working hours." Klein et al found that "the maximal [circadian] variation....in psychomotor performance corresponds to the maximal effect of 0.09 percent blood alcohol" (Reference 15); that is, the effect is roughly comparable to drinking a "small martini on an empty stomach" (Reference 16). Variations in this response among individuals can be expected to vary considerably. However, the possible persistence of 24-hour periodicity in psychomotor performance during many "days" of adherence to a 23.5-hour sleep cycle must be considered conjectural.

Other mechanisms that might tend to degrade crew alertness, enthusiasm, or performance as a direct result of a 23.5-hour sleep cycle could be postulated; these would however be equally speculative.

Thus, with regard to physiological considerations it may tentatively be concluded that: (a) although it is not certain that all AAP-2 astronauts will readily adapt to the shortened sleep cycle, it is likely that they will; and (b) if performance is affected by adherence to such a cycle, there is no present evidence that the effect will be other than small.

5.2 Effects of a 23.5-Hour Crew Day on Medical Monitoring Experiments

MSC's Medical Research and Operations Directorate has reviewed the currently baselined 23.5-hour sleep cycle for AAP astronauts and concluded that medical monitoring experiments will not be adversely affected by this departure from a normal

24-hour cycle (Reference 17). If, however, difficulty is experienced in the crews' adapting to a 23.5-hour sleep cycle, the resulting irregularity in the actual duration of successive crew "days" could introduce significant irregularities into data collected for Experiment M073 - Bioassay of Body Fluids (Reference 18); such irregularities in the data would make comparisons with previously collected baseline data difficult.

5.3 Flight Crew Preference

Flight crew preferences in the present context refer to planning decisions made within MSC's Flight Crew Operations Directorate (FCOD).

The use of a 23.5-hour sleep cycle in AAP missions has been accepted by FCOD for preliminary mission planning purposes, subject to subsequent analysis. While there appears to be a natural crew preference for a 24-hour sleep cycle, there is a strong feeling that whether the number is 24 hours or some value near 24 hours, the length of the scheduled crew "day" should be constant throughout the mission (Reference 19); variable-length "days" are considered to have contributed significantly to crew fatigue and degraded performance during at least one previous mission (Reference 20).

6.0 Summary and Conclusions

Several aspects of the decision to use a 23.5-hour astronaut sleep cycle during AAP missions in place of the "natural" 24-hour cycle have been analyzed. Principal assumptions underlying the present analysis are:

1. Astronauts will maintain a normal nocturnal sleep pattern during the week preceding launch.
2. AAP-2 will be launched on the day following the launch of AAP-1.
3. The AAP-2 flight crew will be scheduled to sleep concurrently throughout the mission.
4. The Saturn Workshop will be launched into a circular orbit having a 35° inclination to the equatorial plane and an initial altitude of 235 nm.
5. No significant phase shift will occur in the astronauts' sleep pattern at the start of the mission.
6. For planning purposes, AAP-2 must be launched in daylight and its crew recovered in daylight at the end of a nominal mission.
7. Crew safety and the likelihood of mission success will be enhanced if EVA's are conducted during periods of relatively frequent direct communication between the spacecraft and the MSFN.
8. It is desirable that EVA's be scheduled in such a way that the astronauts' exposure to ionizing radiation is minimized.

The installation of an Intelsat IV terminal in the Workshop would provide voice communication between the spacecraft and the ground during 80% to 90% of the mission. This would remove the original incentive for using 23.5-hour astronaut sleep cycles, which was to enable the crew to be awake during periods of most frequent contact with the MSFN.

Other considerations may, however, still provide motivation for planning to use the shortened sleep cycle. If AAP-1 is launched at 4:00 PM EST as currently planned, 23.5-hour crew cycles can provide daily EVA scheduling opportunities outside the South Atlantic Anomaly and within

regions of frequent direct spacecraft/MSFN contacts throughout the mission; 24-hour sleep cycles would provide such opportunities only until Day 17 GET. In addition 23.5-hour sleep cycles would require no phase shift in astronaut sleep patterns during the mission whereas adherence to 24-hour cycles would require a phase shift at the end of a nominal 28 day mission. These advantages of 23.5-hour sleep cycles do not, however, apply if AAP-1 is to be launched in the morning.

A brief review of qualitative factors concerning the feasibility of 23.5-hour astronaut sleep cycles has shown that:

1. It is more likely than not that the crew would be able to adapt their sleep pattern to the shortened "day."
2. While adherence to the shorter than normal sleep cycle might conceivably affect crew performance, there is no evidence that such an effect would be other than small.
3. No detrimental effects on biomedical experiments would be expected to result from adhering to a 23.5-hour sleep cycle. However, an unsuccessful attempt to adapt to such a cycle may disrupt sleep patterns in such a way that difficulties might be introduced in the evaluation of data collected for Experiment M073 - Biossay of Body Fluids.
4. Flight Crew Operations has accepted the use of 23.5-hour sleep cycles for mission planning purposes.

As noted above, the conclusions reached in the present study are, in part, the consequence of assuming the Workshop's orbital inclination to be 35°. The effect of the recent baseline change to an inclination of 50° will be examined in a forthcoming memorandum.

7.0 Recommendations

Based upon the analysis presented in this memorandum, it is recommended that 24-hour crew sleep cycles be employed during AAP missions, assuming that:

1. An Intelsat IV terminal is provided in the Workshop, and
2. EVA's can be scheduled both outside the South Atlantic Anomaly and during periods of frequent direct contact with the MSFN.

If these assumptions are not realizable, it is recommended that 23.5-hour crew sleep cycles be employed, provided AAP-1 is launched in the late afternoon as presently planned.

In view of the relative lack of experience with 23.5-hour sleep cycles and the significant disruption of flight plans that could result from an astronaut's inability to adapt to such a sleep pattern, it is further recommended that if shortened sleep cycles are to be used during AAP missions:

1. Consideration be given to ground based tests of human subjects to demonstrate the feasibility of 23.5-hour sleep cycles, and
2. Astronaut training for the AAP-1/AAP-2 mission include a reasonable period of time on a 23.5-hour sleep cycle routine to determine individual adaptability and to provide an opportunity for gathering baseline data on the crews' performance for later comparison with in-flight results.

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